

## Evaluation of defoliant mixtures in cotton\*

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### ABSTRACT

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Current chemical defoliant have limitations which are usually magnified by environmental conditions or the nature of the compound. The objective of this study was to evaluate the effectiveness of various chemical defoliants when used in combination at one-half the standard use rate. Tests were conducted from 1986 to 1988 at the Delta Branch Experiment Station in Stoneville, Mississippi and in 1987 and 1988 at the Plant Science Research Center in Starkville, Mississippi. Chemicals evaluated were tribufos (S,S,S-tributylphosphorotriphosphate), thidiazuron (N-phenyl-N prime-1,2,3-thi-diazol-5-ylurea), dimethipin (2,3-dihydro-5,6-dimethyl-1,4-dithiin 1,1,4,4 tetraoxide), and ethephon [(2-chloroethyl)phosphonic acid]. Standard rates for each chemical defoliant were 1.26, 0.14, 0.35, and 2.24 kg/ha, respectively. When used in two-way combination treatments, each defoliant rate was reduced by one-half. A non-ionic surfactant at 0.25% (v/v) was added to all dimethipin treatments. Defoliation and regrowth estimates were made by visual observations at 5, 7, and 14 days after treatment.

In general, two chemical defoliants tank-mixed at one-half the standard use rate were equal to or superior to either single component applied at the standard use rate. In addition to equal effectiveness, combinations offered additional safeguards against adverse environmental conditions.

### INTRODUCTION

It is axiomatic that chemical termination of cotton improves harvestability and lint quality. Several factors influence the success of crop termination with chemicals. These factors include plant conditions and environmental conditions, especially temperatures, at the time of application, and the type of chemical defoliant used. Chemical defoliants available today provide adequate defoliation if these criteria are optimized. Since environment plays an

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integral part in the successful chemical defoliation of cotton, success is often dependent upon something that cannot be controlled or manipulated. Also, it is sometimes difficult to determine optimum plant conditions or predict plant response under varying plant conditions.

In order to offset unfavorable environmental and/or sub-optimum plant conditions, several factors involved in the use of chemicals for defoliation have been evaluated in the past. Cathey (1978, 1985) reported that TD 1123 (potassium, 3-4-dichloroisoithiazole-5-carboxylate) was an effective harvest aid chemical, especially when environmental conditions were not conducive to easy defoliation. TD 1123 also enhanced several physiological and biochemical responses of cotton leaves to tribufos (Cathey et al., 1981). Compounds such as glyphosate (Cathey and Barry, 1977), paraquat (Cathey, 1979; Cathey et al., 1982), and others (Brown, 1957; Mullins et al., 1972; Cathey et al., 1982) have been used either as additives or as conditioner treatments applied prior to the application of defoliant chemicals. Another study reported that multiple applications at proportional rates of a phosphate defoliant were superior to a single application of the same total amount (Cathey and Hacskeylo, 1971). While some combinations and/or additives have been evaluated, the effectiveness of many have been erratic or have not produced responses of commercial importance.

Data reported in 1982 revealed that a combination of tribufos + ethephon at rates of 1.2 + 2.2 kg/ha, respectively, provided superior defoliation at 7 and 10 days after treatment compared with tribufos or ethephon alone at the same rates (Cathey et al., 1982). Each of these rates is considered the maximum standard use rate when applied alone. Enhanced response from these two compounds suggested the need to evaluate the use of lower rates without reducing performance. The objective of this research was to evaluate the effectiveness of commercially available harvest aids used at the standard use rate or in combinations at one-half the standard use rate.

## MATERIALS AND METHODS

Experiments were conducted at the Mississippi State University, Delta Branch Experiment Station, Stoneville MS, 1986 to 1988, and at the Plant Science Research Center, Starkville MS, 1987 and 1988. Respective soil types for each location were Bosket very fine sandy loam (fine-loamy, mixed, thermic Mollic Hapludalf) and Marietta fine sandy loam (fine-loamy, siliceous, thermic Fluvaquent Eutrochrepts). In 1986, 'DES 422' cotton was planted to 4-row plots that were 16.8 m long with a 1-m row spacing, replicated three times. 'DES 119' was used at both locations in 1987 and 1988. Plots were replicated four times and were four 1-m rows wide and 9.1 m long at Stoneville and 12.2 m long at Starkville. A randomized complete-block de-

sign was utilized in all experiments. Customary production practices, such as planting date, cultivation, fertility, and insect control, for each location were utilized to optimize cotton productivity. Planting dates were 1 May 1986, 26 April 1988, and 28 April 1989 for Stoneville, and 6 May 1987 and 4 May 1988 for Starkville. At Stoneville, cotton was furrow-irrigated twice per season in July or early August. There was no irrigation at the Starkville location. Seeding rates were 21.3 kg/ha and 13.4 kg/ha for Stoneville and Starkville, respectively. Nitrogen at 120 kg/ha was applied preplant at Stoneville and 100 kg/ha was applied at Starkville, with 50% applied preplant and 50% applied as a side-dress application in mid-June.

Defoliants were applied with high-clearance ground equipment calibrated to deliver a carrier volume of 187 l/ha. Sprayers were equipped with hollow cone-type nozzles and were operated at pressures of from 275 kPa to 345 kPa. Treatments and their standard use rates were as follows: (1) untreated control; (2) tribufos at 1.26 kg a.i./ha; (3) dimethipin at 0.35 kg a.i./ha plus non-ionic surfactant (NIS) at 0.25% (v/v); (4) thidiazuron at 0.14 kg a.i./ha; and (5) ethephon at 2.24 kg a.i./ha. When two defoliants were combined, the standard use rate of each defoliant was reduced by one-half. All treatments involving dimethipin contained non-ionic surfactant at 0.25% v/v.

At Stoneville, visually estimated crop stages at time of application were from 50 to 75% open bolls in 1986 and 70 to 80% in 1987. In 1988, percent open was calculated to be 71% at Stoneville. At Starkville, cotton was calculated to be 60% and 45% open for 1987 and 1988 respectively. Percent open bolls was determined by counting total and open bolls in a 1-m row section from the untreated control plot of each replication.

Visual estimates of percent defoliation were made at 5, 7, and 14 days after treatment (DAT). At 14 DAT, percent regrowth was visually estimated using a rating scale of 0–100, where 0 was no new growth occurring on the plant and 100 was total re-occurrence of new growth. Visual estimates were made from the two center rows of each plot. All data were subjected to an analysis of variance and means were separated using Duncan's multiple-range test at the 5% level of probability.

## RESULTS AND DISCUSSION

In 1986, combination treatments applied at one-half the standard rate were as good or better than either component alone at the standard use rate. Tribufos + thidiazuron was better than thidiazuron alone at 5 DAT (Table 1) and 7 DAT (Table 2) in 1986. At 7 and 14 DAT (Table 3), this combination was better than tribufos alone, which reflects the degree of regrowth control apparent with the use of thidiazuron compared with tribufos alone. Also, greater defoliation with tribufos + thidiazuron at 7 DAT indicated a faster response time than thidiazuron alone, since they were equal at 14 DAT. However, this

TABLE 1

Percent defoliation five days after application of various chemical defoliant<sup>1</sup>

Chemical treatment	Rate (kg/ha)	Defoliation %				
		Stoneville			Starkville	
		1986	1987	1988	1987	1988
Control	—	—	1e	0d	6e	0c
Tribufos	1.26	63ab	65a	71abc	47a	10ab
Dimethipin + NIS <sup>2</sup>	0.35	63ab	28cd	71abc	22b-e	10ab
Thidiazuron	0.14	60b	19d	82a	10de	0c
Ethephon	2.24	65ab	24cd	60c	32a-d	8abc
Tribufos + dimethipin + NIS	0.63+0.17	73ab	68a	76ab	42ab	10ab
Tribufos + thidiazuron	0.63+0.07	78a	51b	78ab	35abc	2bc
Tribufos + ethephon	0.63+1.12	72ab	61ab	77ab	39ab	10ab
Thidiazuron + dimethipin + NIS	0.07+0.17	63ab	26cd	74ab	12cde	8abc
Thidiazuron + ethephon	0.07+1.12	68ab	25cd	81a	22b-c	8abc
Ethephon + dimethipin + NIS	1.12+0.17	45c	31c	69bc	30a-d	15a

<sup>1</sup>Means within columns followed by the same letter are not significantly different at the 5% probability level according to Duncan's multiple-range test.

<sup>2</sup>NIS = Non-ionic surfactant at 0.25% v/v.

TABLE 2

Percent defoliation seven days after application of various chemical defoliant<sup>1</sup>

Chemical treatment	Rate (kg/ha)	Defoliation (%)				
		Stoneville			Starkville	
		1986	1987	1988	1987	1988
Control	—	—	0d	0e	10e	0e
Tribufos	1.26	71bcd	79a	72cd	57a	15bc
Dimethipin + NIS <sup>2</sup>	0.35	67cde	34c	77bcd	30b-e	12bcd
Thidiazuron	0.14	80bc	26c	92a	17de	2de
Ethephon	2.24	78bc	28c	70d	36a-d	22ab
Tribufos + dimethipin + NIS	0.63+0.17	85ab	74ab	82abc	47ab	15bc
Tribufos + thidiazuron	0.63+0.07	97a	69b	91a	50ab	10cd
Tribufos + ethephon	0.63+1.12	81b	75ab	83ab	42abc	18bc
Thidiazuron + dimethipin + NIS	0.07+0.17	73bcd	35c	86ab	22cde	12bc
Thidiazuron + ethephon	0.07+1.12	83b	29c	90a	25cde	10cd
Ethephon + dimethipin + NIS	1.12+0.17	56e	35c	77bcd	32bcd	28a

<sup>1</sup>Means within columns followed by the same letter are not significantly different at the 5% probability level according to Duncan's multiple-range test.

<sup>2</sup>NIS = Non-ionic surfactant at 0.25% v/v.

TABLE 3

Percent defoliation and regrowth of cotton 14 days after application of various chemical defoliant<sup>1</sup>

Chemical treatment	Rate (kg/ha)	Defoliation (%)				Regrowth (%)			
		Stoneville		Starkville		Stoneville		Starkville	
		1986	1987	1988	1987	1988	1987	1988	1987
Control <sup>1</sup>	—	--	19d	0	17e	8f	9d	29d	20abc
Tribufos	1.26	62bc	83a	88cd	72b	42bc	40a	54a	36ab
Dimethipin + NIS <sup>2</sup>	0.35	61bc	46b	88cd	37d	35cd	12cd	46b	21abc
Thidiazuron	0.14	83a	31c	98a	37d	18ef	11cd	6e	5c
Ethephon	2.24	77ab	35bc	84d	50d	58ab	18bc	26d	32abc
Tribufos + dimethipin + NIS	0.63+0.17	80a	77a	91bc	70bc	42bc	35a	36c	40a
Tribufos + thidiazuron	0.63+0.07	87a	72a	94ab	82a	22def	16bcd	11e	6bc
Tribufos + ethephon	0.63+1.12	77ab	75a	90bcd	50d	42bc	34a	32cd	42a
Thidiazuron + dimethipin + NIS	0.07+0.17	80a	34bc	92abc	37d	25cde	11cd	11e	16abc
Thidiazuron + ethephon	0.07+1.12	83a	31c	96ab	50d	32cde	16bcd	12e	4c
Ethephon + dimethipin + NIS	1.12+0.17	55c	35bc	86cd	52cd	62a	19bc	39c	45a

<sup>1</sup>Means within columns followed by the same letter are not significantly different at the 5% probability level according to Duncan's multiple range test.

<sup>2</sup>NIS, Non-ionic surfactant at 0.25% v/v.

did not occur in 1988. At 14 DAT, thidiazuron was equal to the tribufos+thidiazuron combination (Table 3). By 14 DAT, all combinations except ethephon+dimethipin were comparable. Ethephon+dimethipin provided less than 60% defoliation for all evaluation dates in 1986. The replacement of the non-ionic surfactant used in dimethipin treatments with a non-phytotoxic paraffinic oil may have improved the performance of dimethipin treatments<sup>1</sup>. Overall defoliation did not improve at 14 DAT over that of the 7 DAT evaluation, indicating maximum response of most treatments to be 7 days. Heat-unit accumulation in 1986 at the time of application and for six days following application was considered favorable for optimum defoliant activity (Table 4).

In 1987, rainfall within 6 h of application at both locations reduced the response of most treatments. At Stoneville, rainfall delayed maximum response until 14 DAT where tribufos, and all combinations including tribufos, provided equal defoliation and were superior to all other treatments. This indicated that tribufos and tribufos combinations remained more active than other treatments when rainfall occurred within 6 h of application. The same was true for Starkville, although some treatments did not perform as well as they did at Stoneville (Table 3). At Starkville, the tribufos+ethephon combination at 14 DAT was significantly less than the tribufos, tribufos+dimethipin or tribufos+thidiazuron treatments (Table 3). Apparently, the activity of ethephon was lessened at Starkville by cool temperatures after application (Table 4) and the lower rates of tribufos and ethephon used in the two-way combination.

TABLE 4

Daily heat-unit accumulation (DD<sub>60</sub>)<sup>a</sup> for six days post-application of chemical defoliant to field-grown cotton

Heat units (DD60)																		
Stoneville									Starkville									
1986			1987			1988			1987			1988						
Sept.	17	20	Aug.	28	20	Sept.	16	18	Sept.	19	10	Oct.	7	4				
	18	20			29		16			17	22			20	8		8	5
	19	22			30		14			18	22			21	11		9	3
	20	20			31		16			19	21			22	10		10	3
	21	18	Sept.	1	14		20	22			23		4		11	3		
	22	19			2	12		21		22			24	4		12	4	
Mean		20			15			21			8			3				

<sup>a</sup>(DD<sub>60</sub>) = (Daily max temp (°F) + daily min temp (°F)/2) – 15.

<sup>1</sup>Harvade-5F, Harvest Growth Regulant for Cotton, 1989, Label Requirements, Uniroyal Chemical Company, Inc., Middlebury, CT 06749, U.S.A. EPA Reg. No. 400-155.

Although defoliation with thidiazuron was reduced to less than 40% in 1987 due to rainfall within 24 h of treatment, regrowth prevention was superior to that for tribufos for both locations (Table 3). However, poor defoliation with thidiazuron negated or lessened the regrowth response of the plant. This was supported by the fact that regrowth following ethephon and dimethipin application, both of which do not typically inhibit regrowth as well as thidiazuron, was similar to that of thidiazuron.

In 1988, at Stoneville, all combination treatments were equal or superior to the corresponding single full use rates. At 14 DAT, thidiazuron, tribufos+thidiazuron, thidiazuron+dimethipin, and thidiazuron+ethephon provided better than 92% defoliation. Defoliation at 14 DAT was, overall, greater than at 7 DAT. In 1988, environmental conditions at the time of application and heat-unit accumulation after application favored increased defoliation more than any other year or location. They also enhanced regrowth potential. A single application of tribufos allowed 54% regrowth in 1988 compared with 46% regrowth for dimethipin (Table 3). However, thidiazuron alone, and in combination with tribufos, dimethipin, or ethephon, reduced regrowth to less than 15%. Regrowth inhibition with thidiazuron was not affected even when the rate was reduced 50% for the combination treatment. Tribufos+ethephon reduced regrowth below that of tribufos alone, but regrowth was still greater than with all thidiazuron treatments. In 1988, at Starkville, lowered heat-unit accumulation after application (Table 4) reduced defoliant activity to less than 60% for all treatments. However, at 14 DAT, ethephon+dimethipin was better than all other two-way combination treatments. Thidiazuron, and combinations including thidiazuron, were least effective.

In conclusion, two defoliants tank-mixed at one-half the standard use rate were equal to or superior to either single component applied at the standard use rate. In addition to equal effectiveness, combinations offered additional safeguards against unusual environmental conditions. For example, the use of tribufos or combinations including tribufos were effective when rainfall occurred within 6 h of application, whereas other defoliant mixtures failed. Also, in years where heat-unit accumulation favored regrowth, such as in 1988, reducing the thidiazuron rate by one-half in a combination treatment did not reduce regrowth inhibition, and maintained a high percent defoliation.

Another consideration with respect to proper selection of two-way defoliant tank-mixes is that of accelerated boll dehiscence with the use of ethephon (Cathey et al., 1982). Under optimum conditions and appropriate rates, ethephon accelerates boll dehiscence. This in turn allows for a higher percentage of the crop to be harvested earlier. As a component of a two-way tank mix for optimizing defoliation, accelerated boll dehiscence would be an added advantage in the use of ethephon.

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